Short Range Correlations and the EMC Effect

Or Hen

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In collaboration with:

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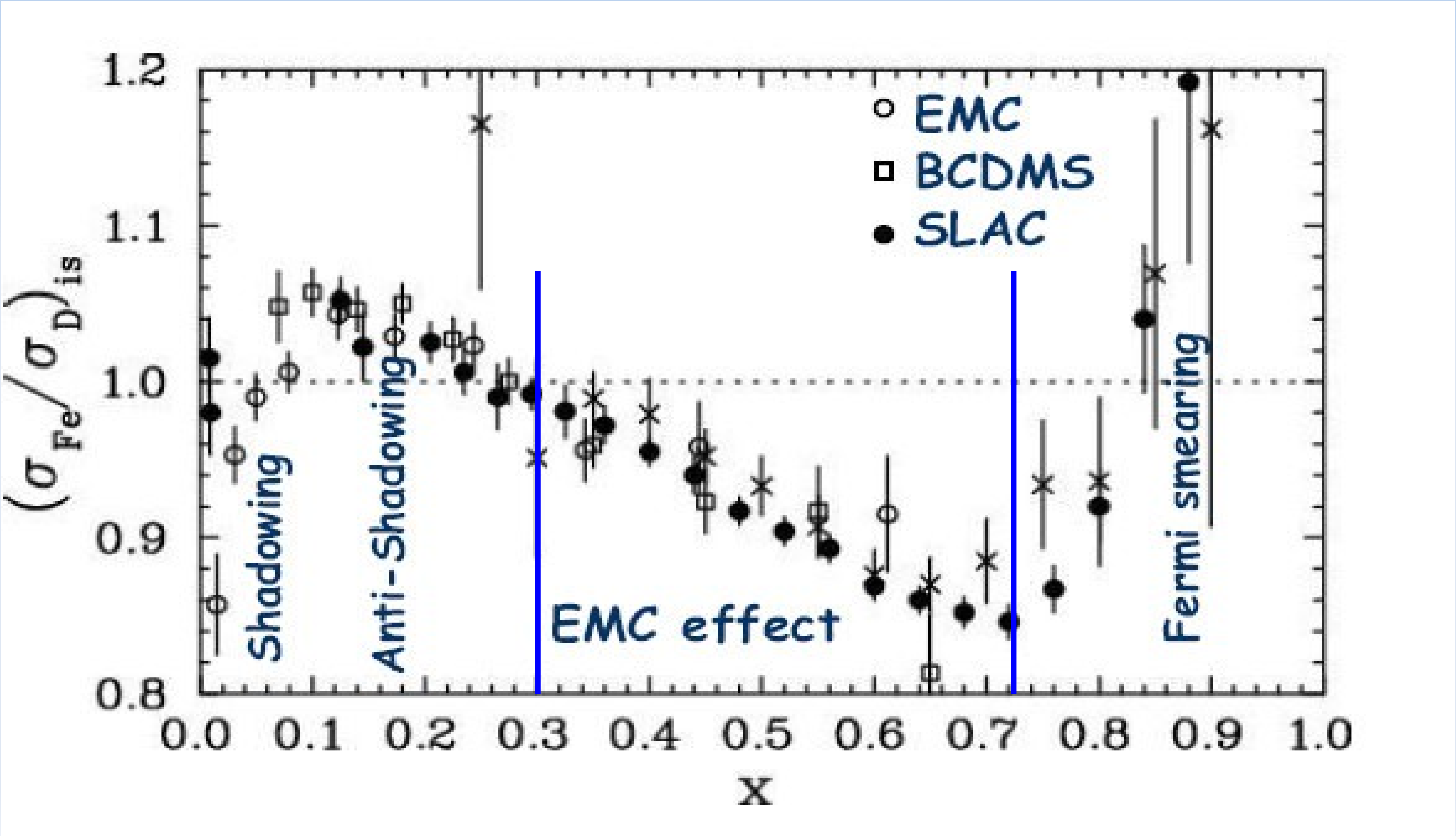
XIX International Workshop on Deep-Inelastic Scattering, Newport News VA, April 2010

EMC Effect

DIS off a bound nucleon ≠ DIS off a free nucleon



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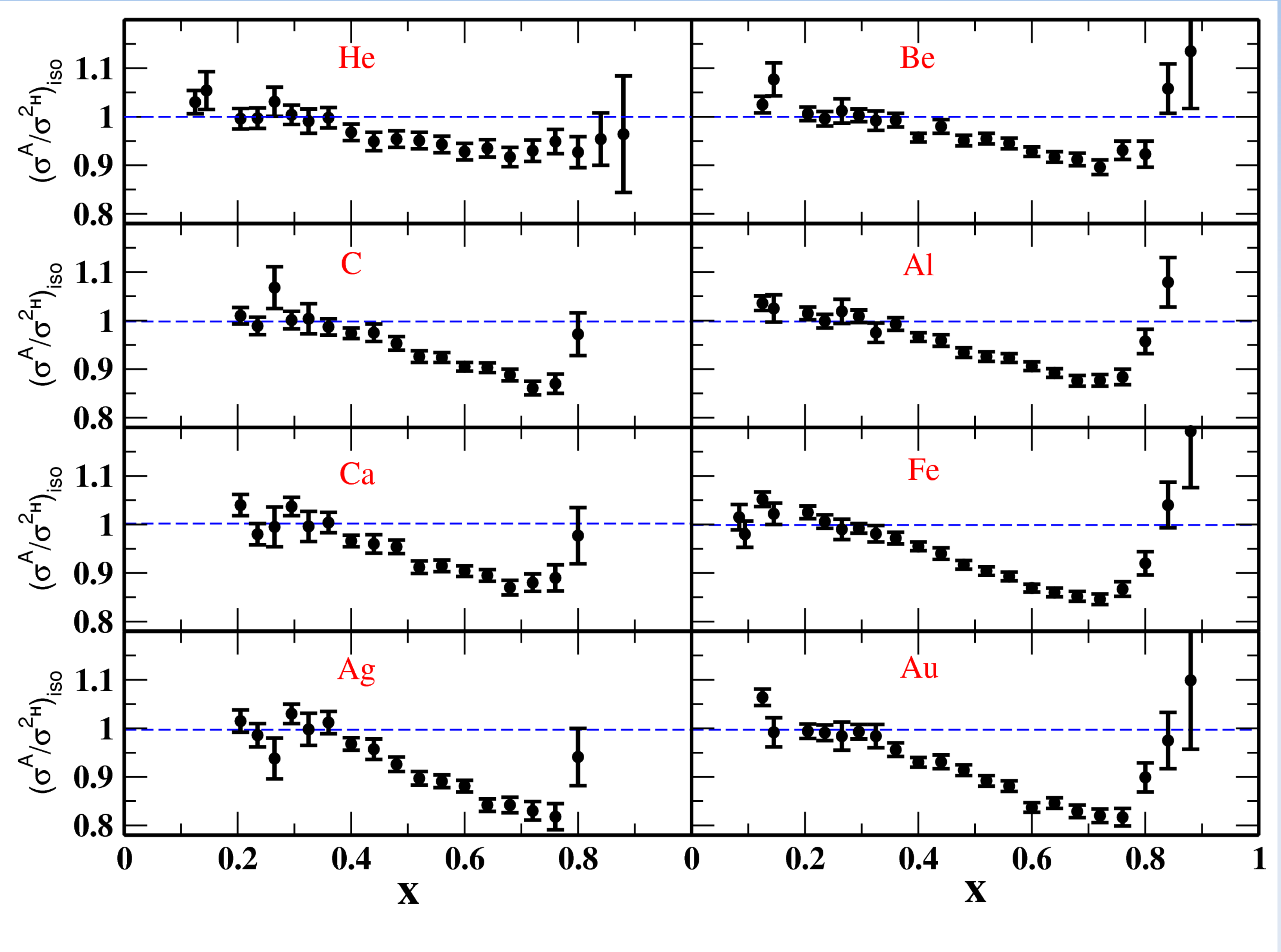


J. Gomez et al., Phys. Rev. D 49, 4348 (1994)

EMC Effect

DIS off a bound nucleon ≠ DIS off a free nucleon

Hundreds of theoretical papers tried to explain the effect

- **Nuclear Effects:** binding effects, pion enhancement, 6-quark clusters, and many more...
- **Modification of the nucleon structure:** dynamical rescaling, point like configuration suppression, structure function modification in the mean field, and many more...

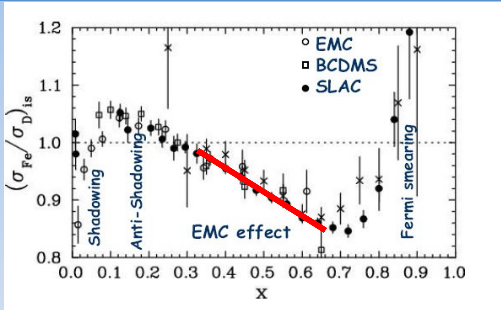
G. Miller: EMC = Every Model is Cool

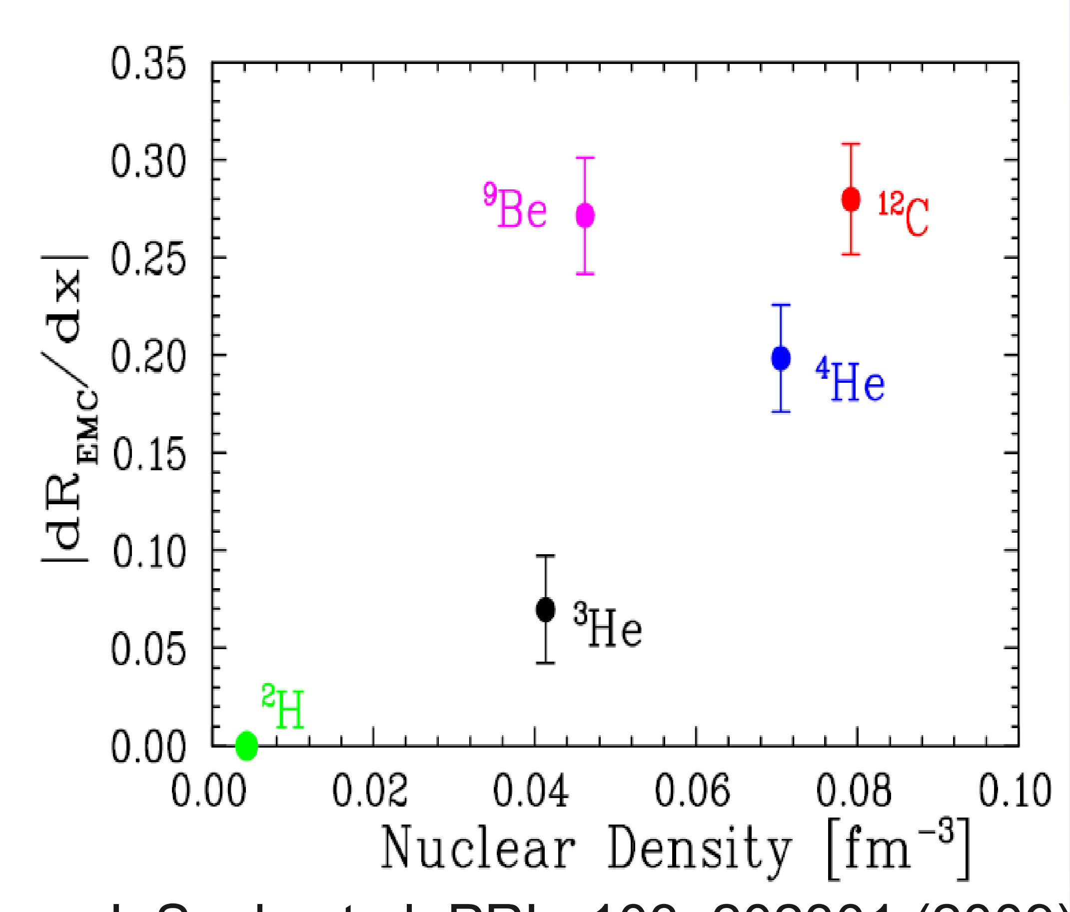
JLab Measurements in Light Nuclei

- Precise DIS measurements in light nuclei
- EMC does not scale as the average nuclear density

→ Not a bulk property

of the nuclear medium

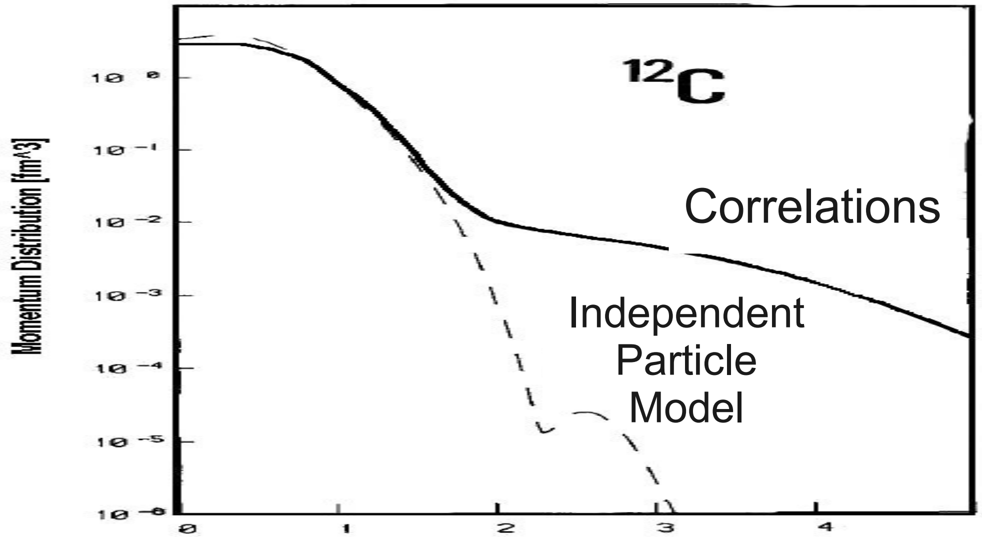


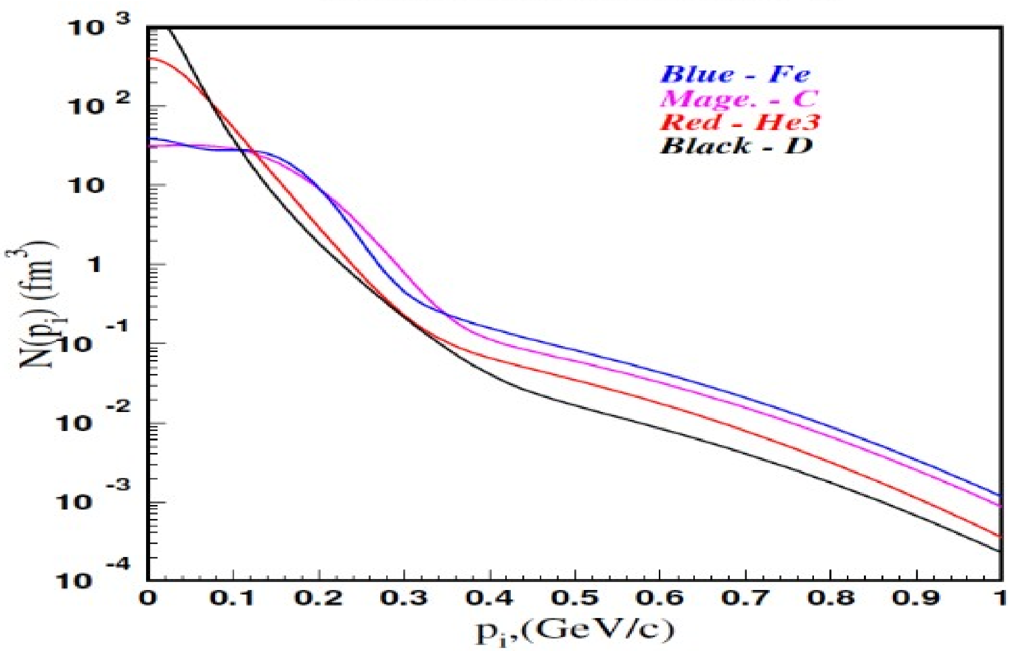


EMC IS A LOCAL DENSITY EFFECT

J. Seely et al. PRL 103, 202301 (2009)

High Momentum Components of the Nuclear Wave Function





- Single particle mean field models do not produce enough high momentum nucleons
- Many-body calculations of nucleon momentum distribution in nuclei predicts that the high momentum distribution for all nuclei has the same shape: $n_A(k) = a_2(A)\cdot n_d(k)$

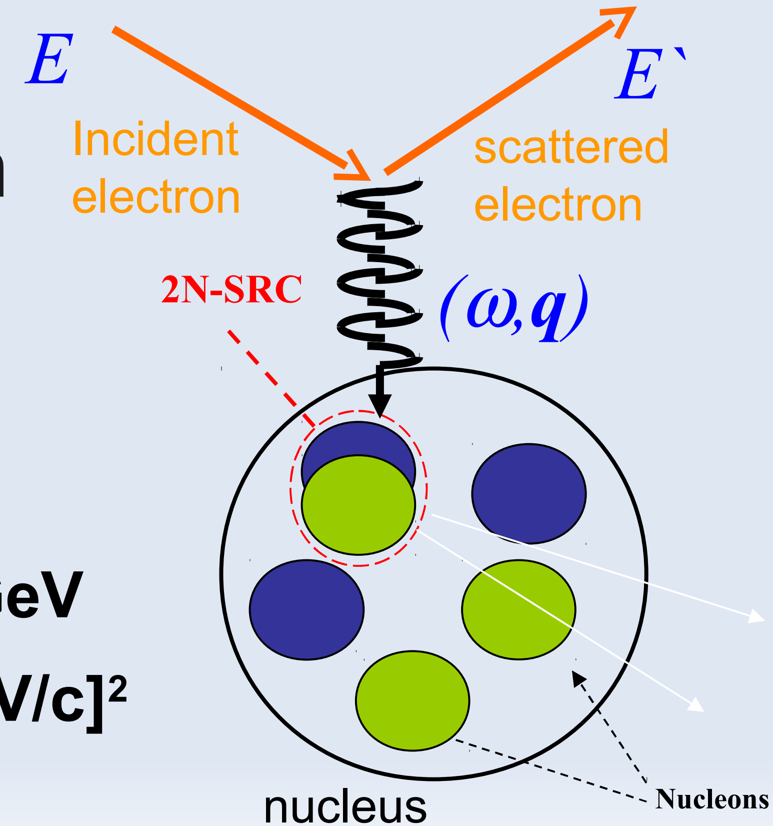
C. Ciofi degli et al. Phys. Rev. C **53** (1996) 1689

Inclusive Electron Scattering at $X_B>1$

- A hard process with the resolving power to probe the **partonic structure of the nucleus**
- $0 < X_B < A$
- X_B counts the number of nucleons involved in the reaction

  $\rightarrow$ for $X_B > j$, at least j nucleons

  are involved in the reaction



Kinematical regime:
E , E' 3 - 5 GeV
Q^2 2 - 3 [GeV/c]^2
$0 \leq X_B \leq A$

Inclusive Electron Scattering at X_B>1

Deep Inelastic Scattering

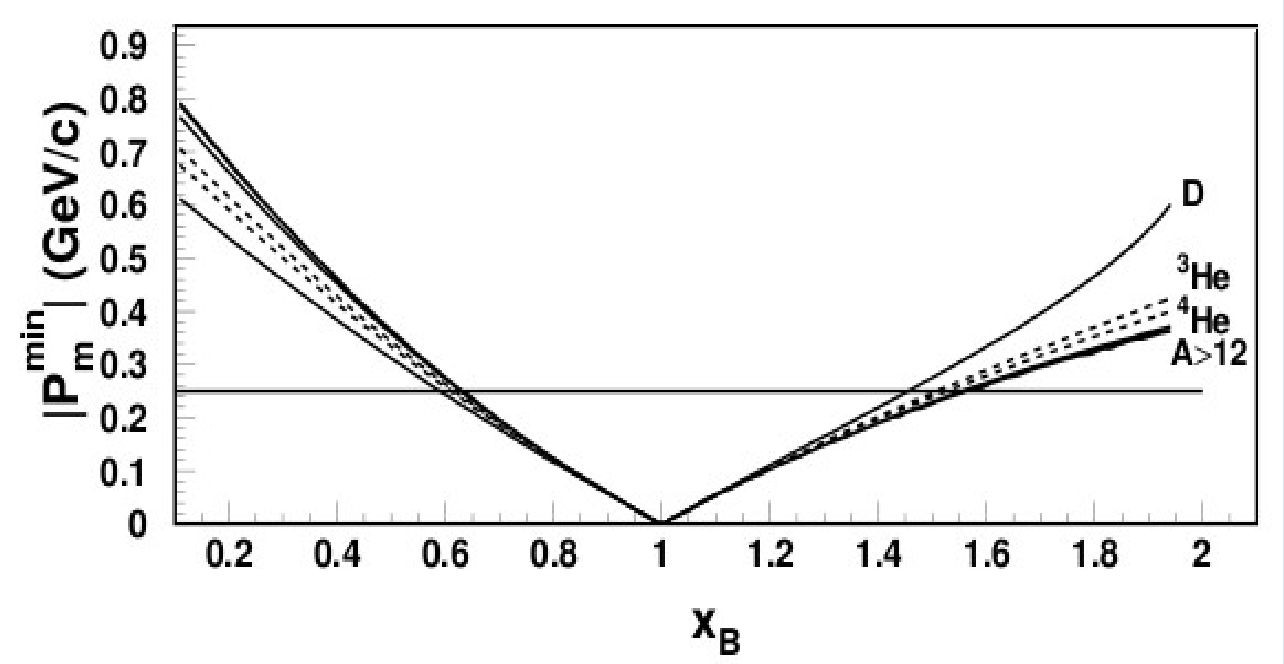
→ Partonic (quark) Structure of **Hadrons**

Inclusive Scattering at X_B>1

→ Partonic (nucleon) Structure of **Nuclei**

Inclusive A(e,e') Measurments

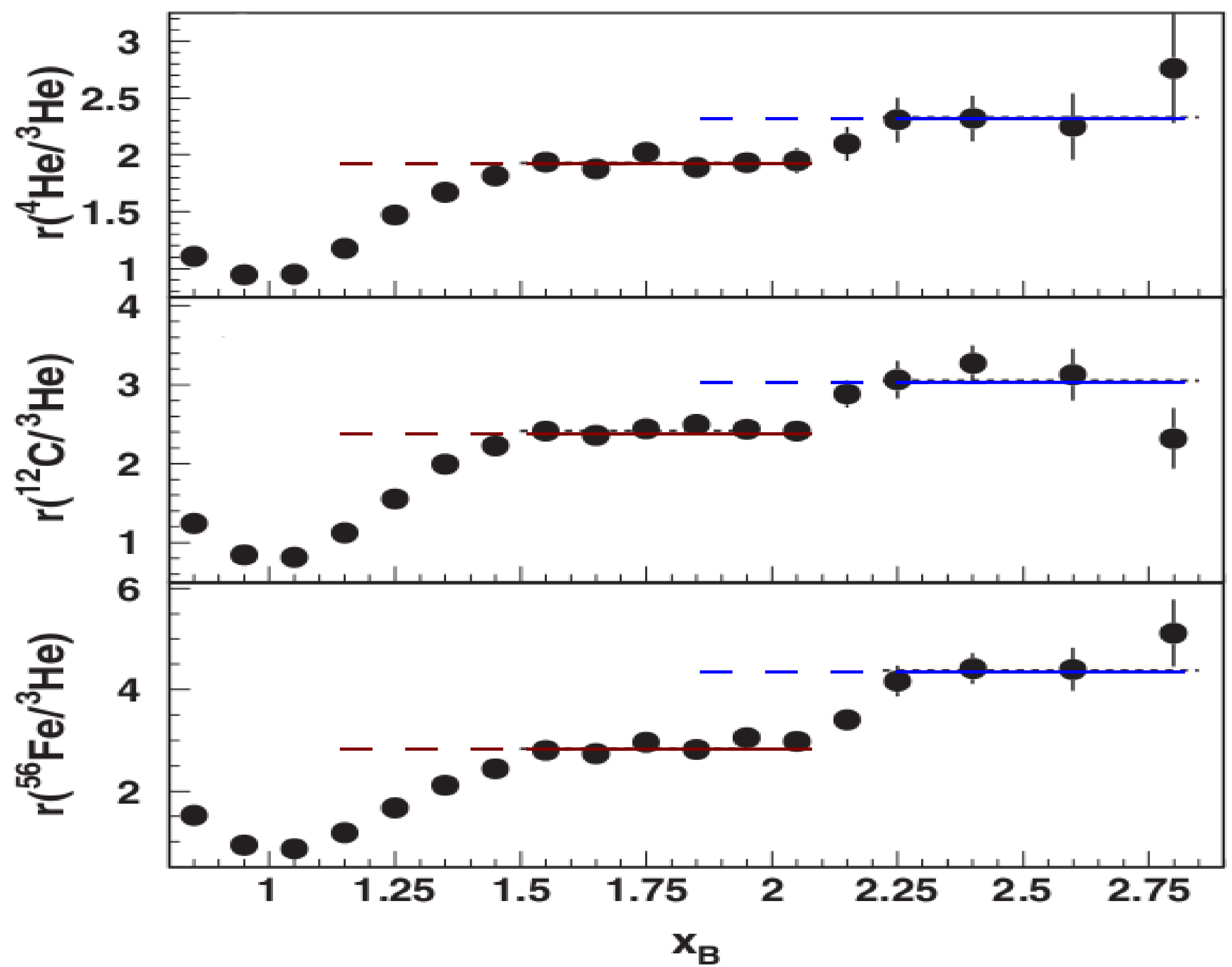
- Energy and momentum conservation for quasi-elastic scattering is given by: $(q+P_A-P_{A-1})^2=m_N^2$
- For high Q^2 and $X_B > 1$ a solution is possible only if the initial momentum of the scattered nucleon is higher than a minimal momentum $P_{min}(X_B)$
- $\rightarrow$ **X_B effectively determines the initial momentum of the scattered nucleon**



momentum scaling $\leftrightarrow$ X_B Scaling

Inclusive A(e,e') Measurments

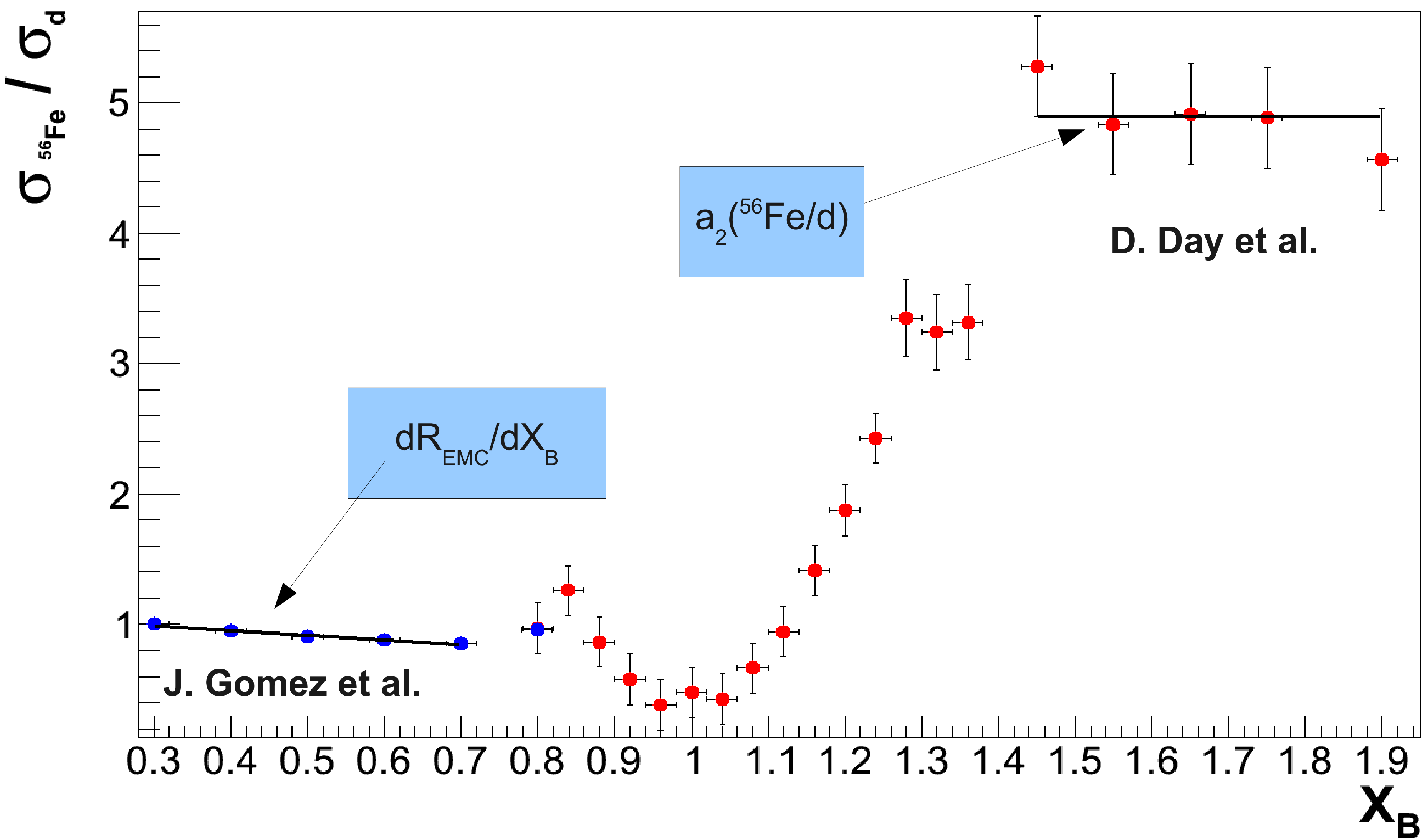
JLab Hall-B



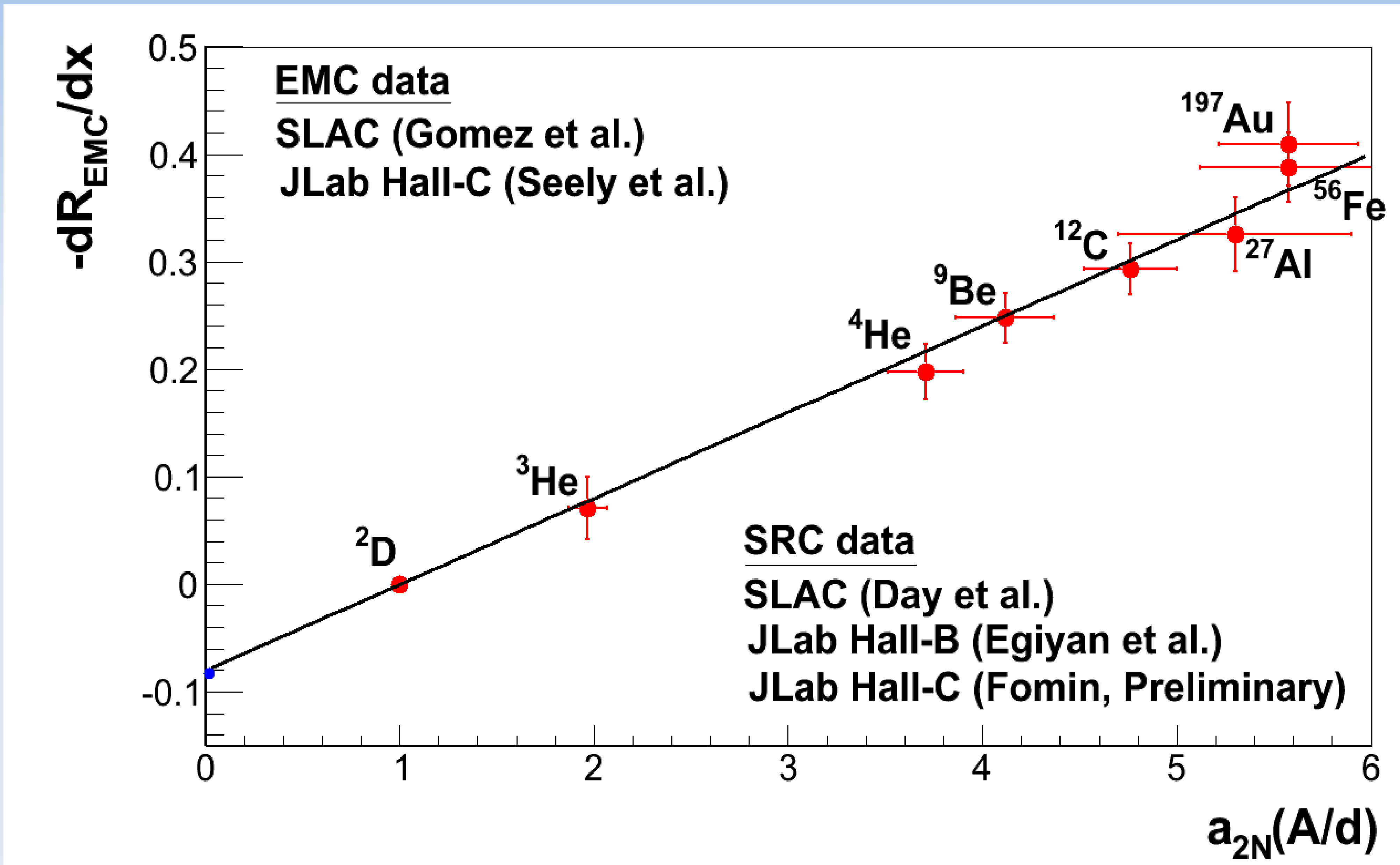
$n_A(k) = a_2(A) \cdot n_d(k) \Rightarrow n_A(k)/n_d(k) = a_2(A)$

K. Sh. Egiyan et al. PRL. 96, 082501 (2006)

Looking at the Full Picture



SRC Scaling Ratios vs. EMC Slopes



L. B. Weinstein et al. PRL. 106, 052301 (2011)

Possible explanations for EMC-SRC correlation

- **The EMC effect is related to high momentum nucleons in the nucleus**
- Contradicts many models that explain the effect in terms of partonic structure function modification by the nuclear mean field
- Supports models that relate the magnitude of the EMC effect to the kinetic energy of the nucleons.
  - Reminder: 2N-SRC holds ~80% of the total kinetic energy of the nucleus

Summery and outlook

- The EMC effect is a local density effect, not a bulk property of the nuclear medium.
- The EMC strength (slopes) scales linearly with SRC probabilities (scaling factors).
- Our speculation is that this correlation arises because both EMC and SRC are dominated by high momentum nucleons in the nuclei.
- Dedicated exclusive and inclusive experiments at JLab 12GeV can help understand the origin of the EMC-SRC correlation
- Implications on PDFs and free nucleon stucture functions ==> **SEE NEXT TALK by Eli Piasetzky**

Thank You!

Extra Slides

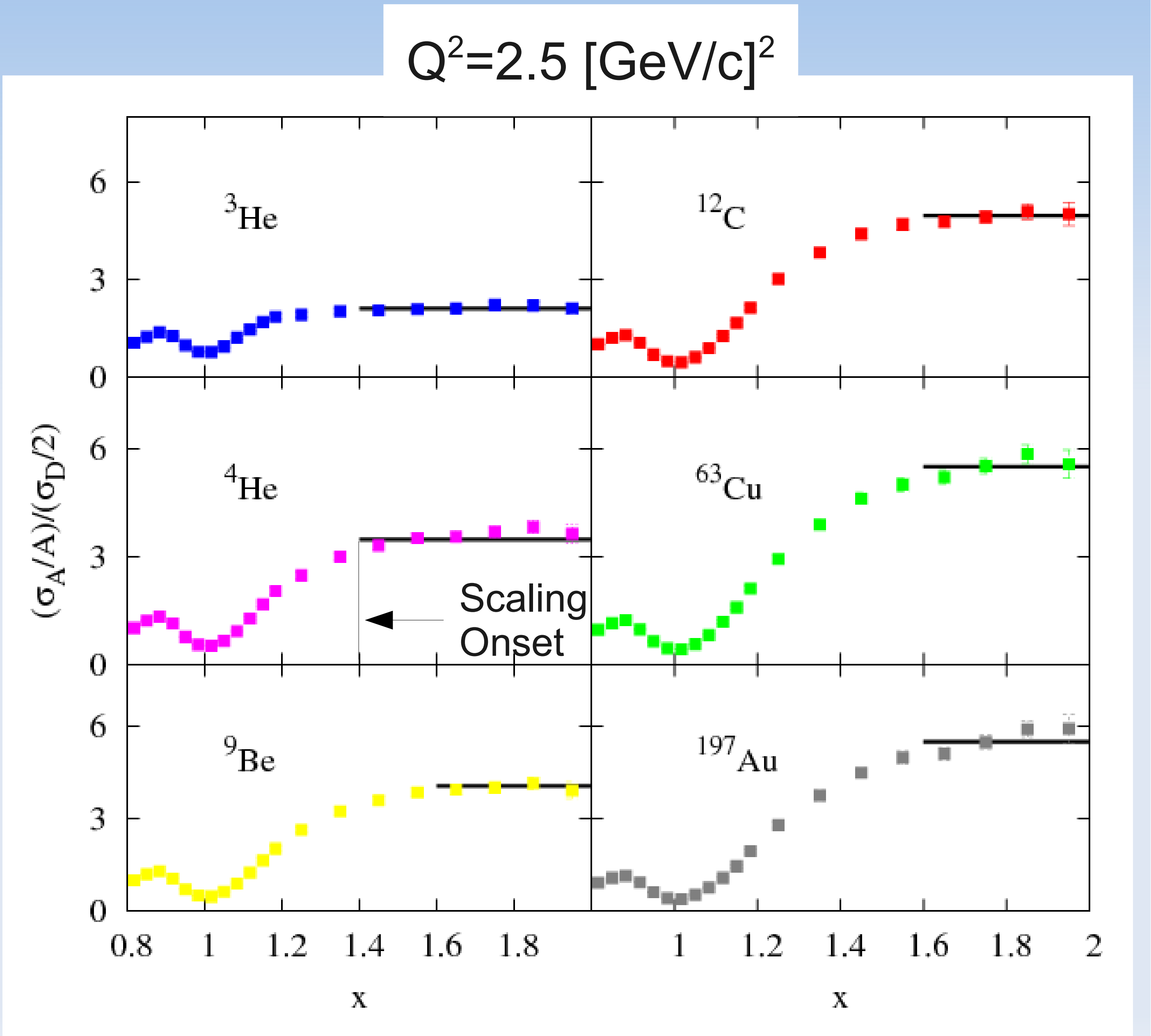
- SRC from inclusive and exclusive measurements
- SRC Q^2 Independence
- EMC Q^2 Independence
- EMC Slope vs. Average
- JLab EMC Results

SRC from inclusive and exclusive measurements

Preliminary Results From JLab Hall-C

$a_2(A/d)$	
^3He	2.08 ± 0.01
^4He	3.47 ± 0.02
^9Be	4.03 ± 0.04
^{12}C	4.95 ± 0.05
^{63}Cu	5.48 ± 0.05
^{197}Au	5.43 ± 0.06

$n_A(k) = a_2(A/d)\cdot n_d(k)$



N. Fomin, Ph.D Thesis (2010)

Short Range Correlations From Inclusive Measurements

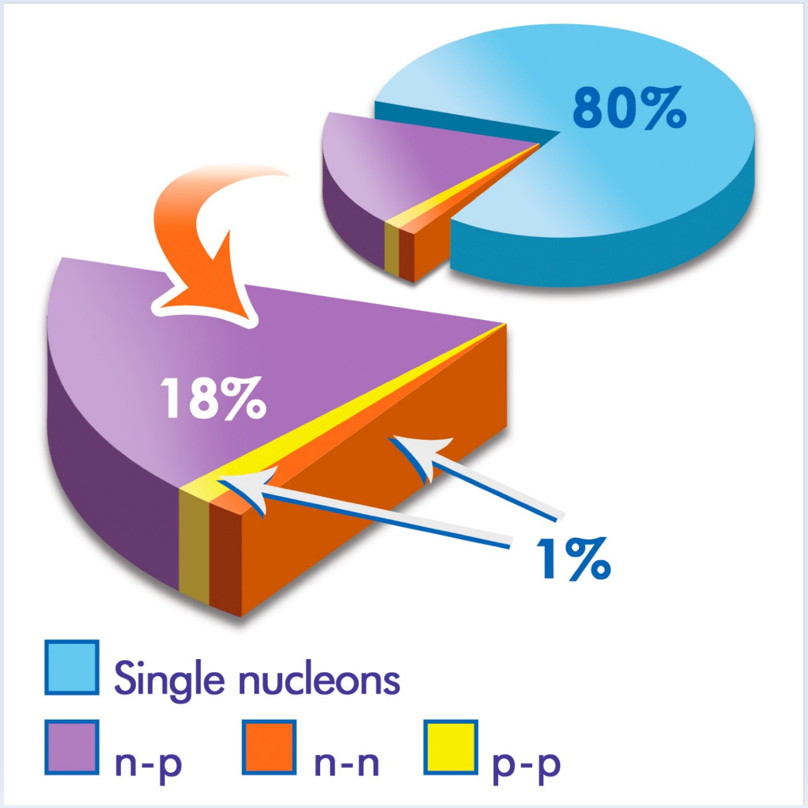
- Scaling onset corresponds to $P_{min} \approx 275$ MeV/c

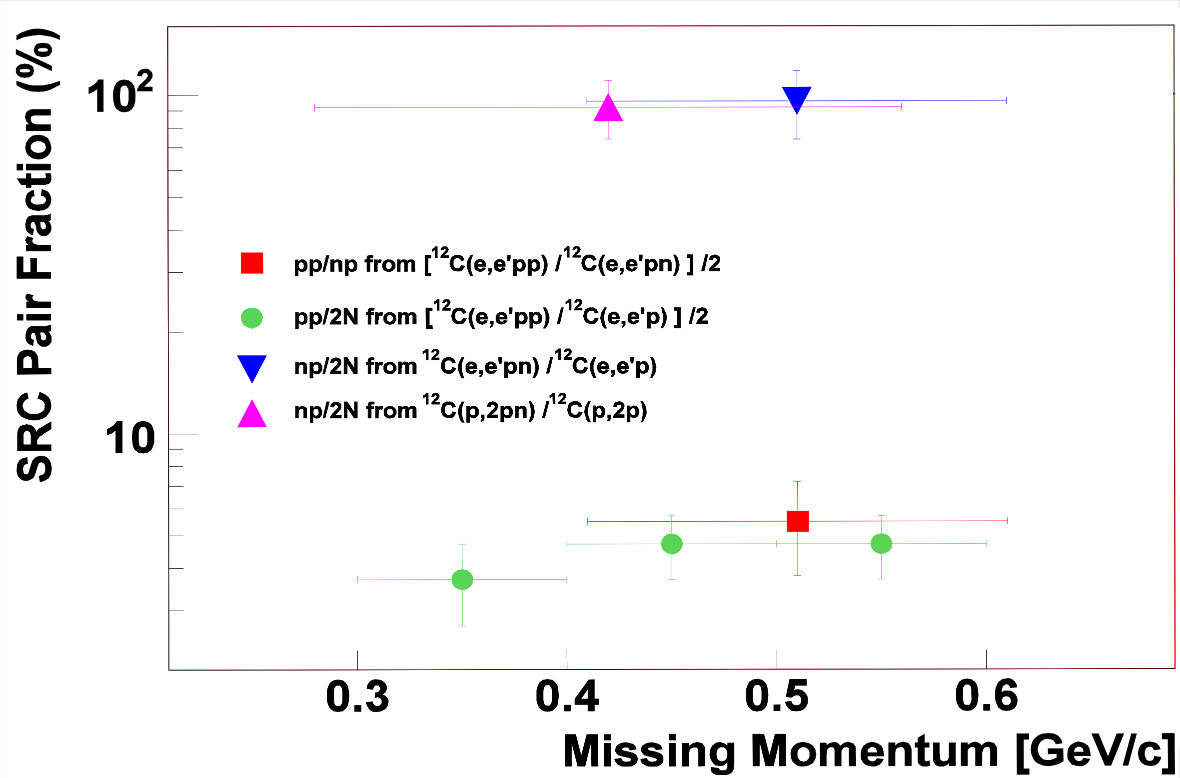
$$\int_0^\infty n_d(k)k^2\,dk = 100\% \quad ==> \quad \int_{P_{min}}^\infty n_d(k)k^2\,dk = 4\%$$

- In nuclei with A > 12, 2N-SRC account for:
  - ~20% of the nucleons in the nuclei
  - ~80% of the kinetic energy carried by the nucleons
- 3N-SRC are an order of magnitude less abundant then 2N-SRC

Exclusive SRC measurements via the (e,e'pN) reaction

- Exclusive measurements at X_B>1 confirmed that the high momentum tail of the nuclear wavefunction consists mainly of 2N-SRC
- These correlations are dominated by np pairs

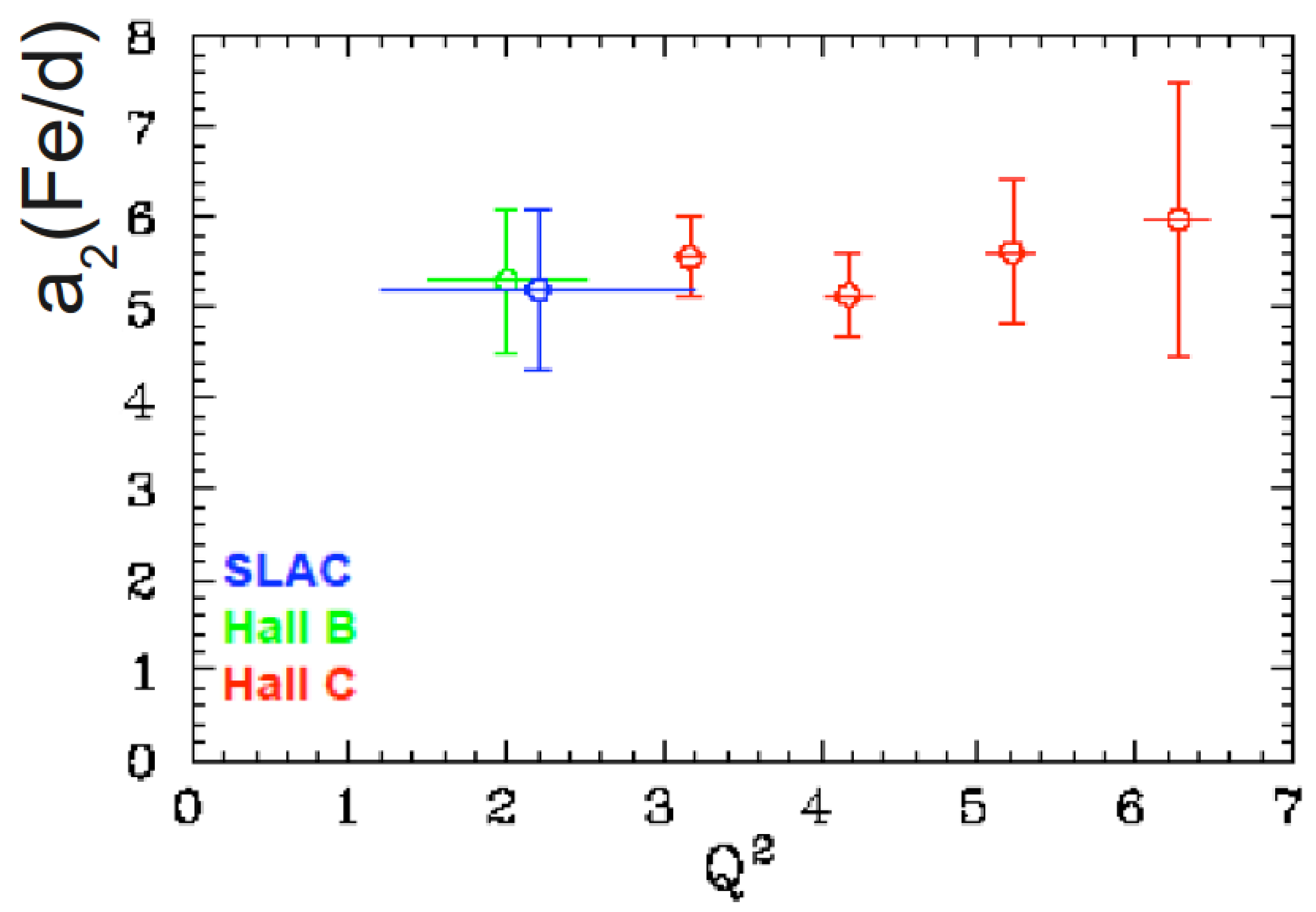




R. Subedi et al., Science 320, 1476 (2008).

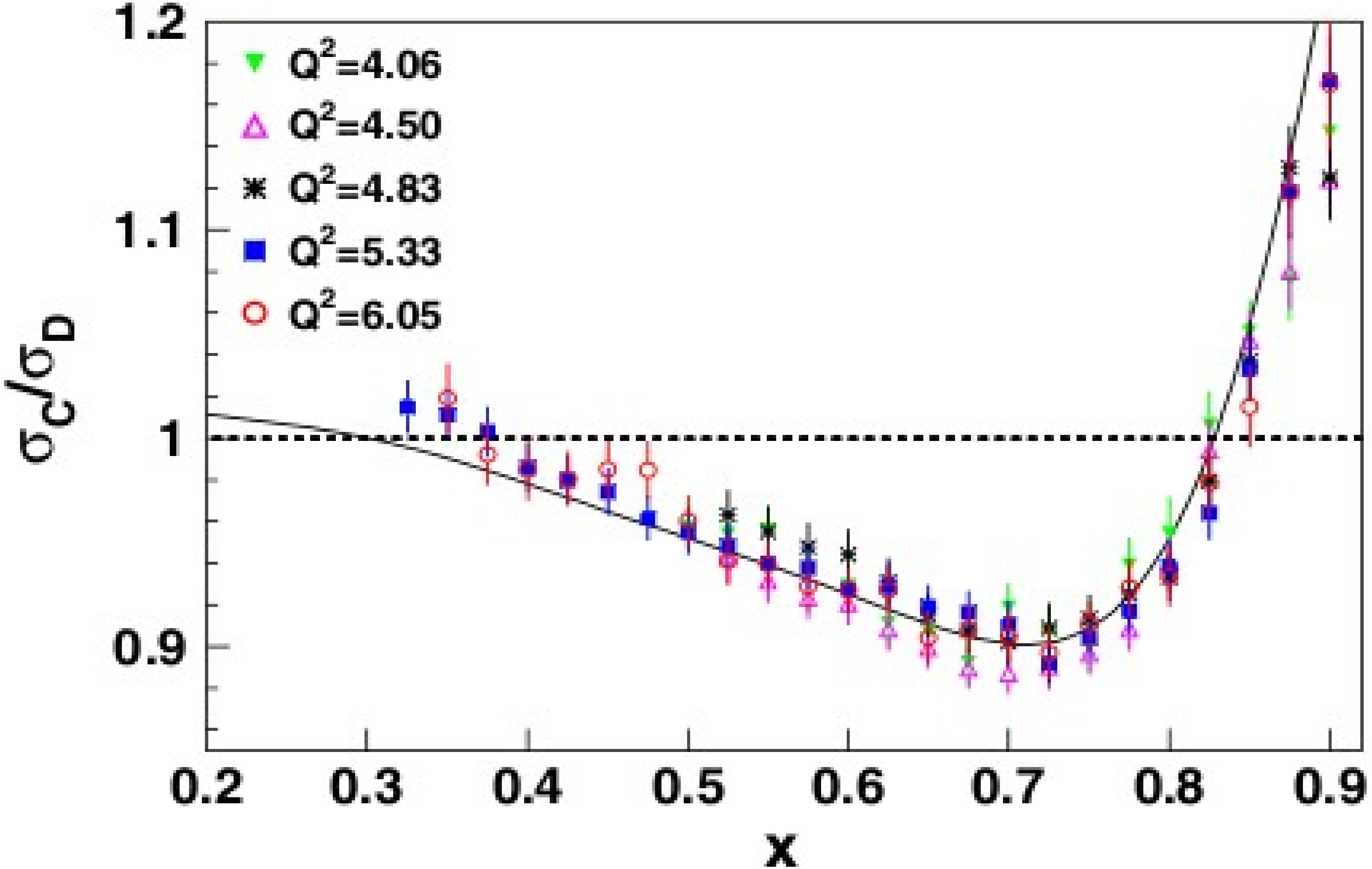
SRC Q^2 Independence

a_2(Fe/d) Q^2 independence



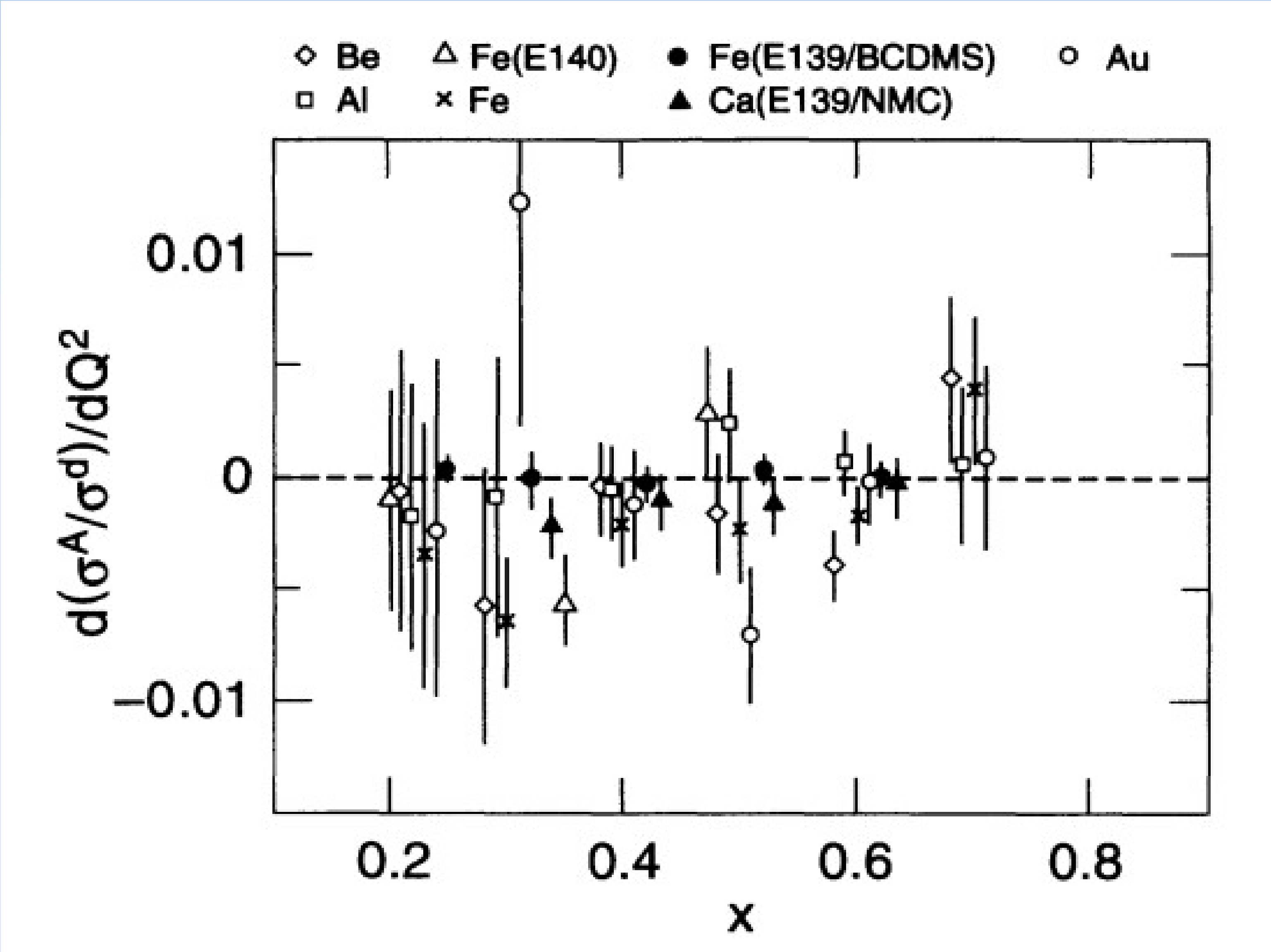
EMC Q^2 Independence

$^{12}C/d$ for $4 < Q^2 < 6$ [GeV/c]^2



J. Seely et al. PRL 103, 202301 (2009)

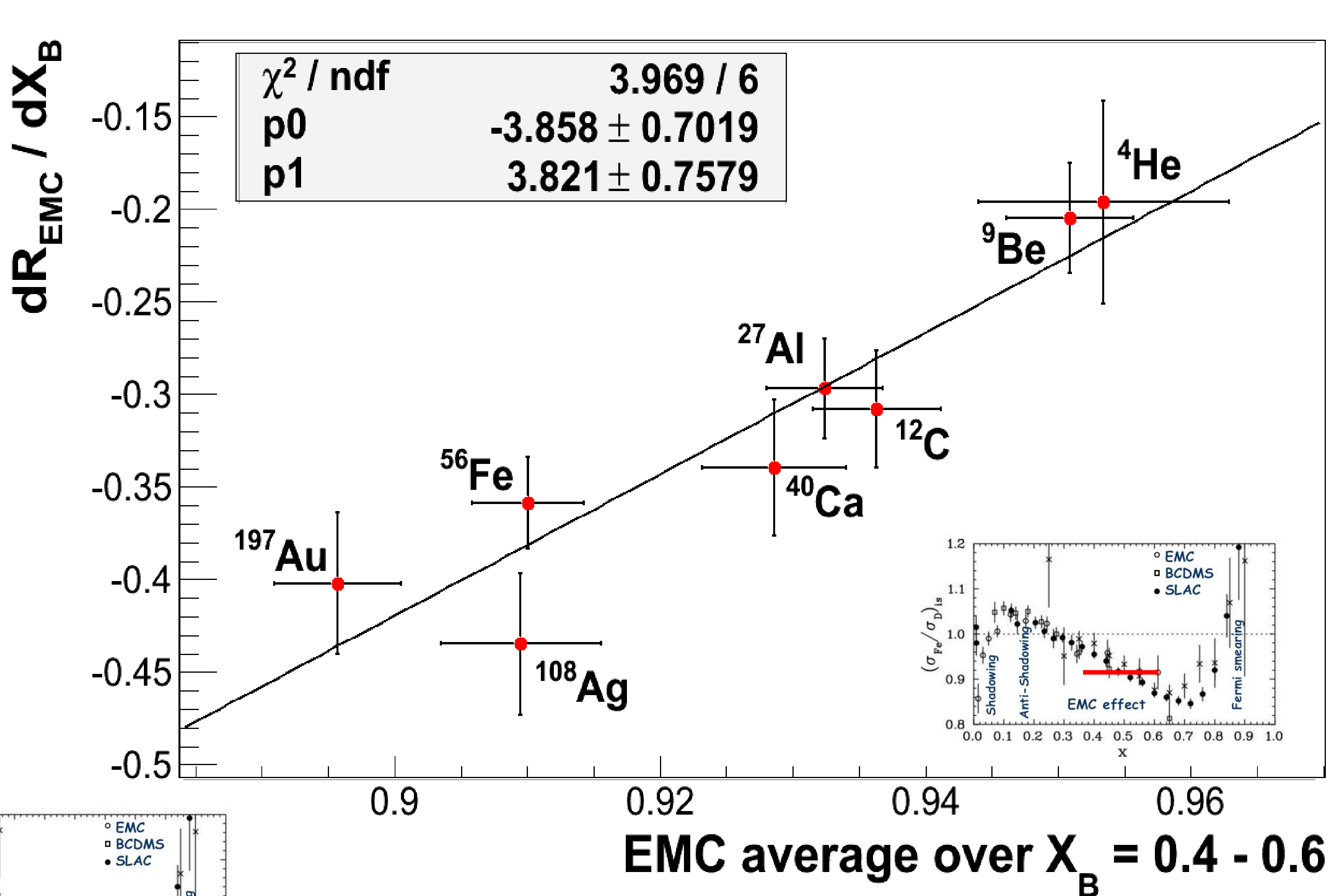
Q^2 independence

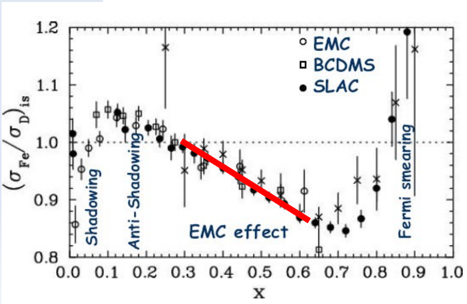


J. Gomez et al., Phys. Rev. D 49, 4348 (1994)

EMC Slope vs. Average

EMC slope vs. average of X_B=0.4-0.6

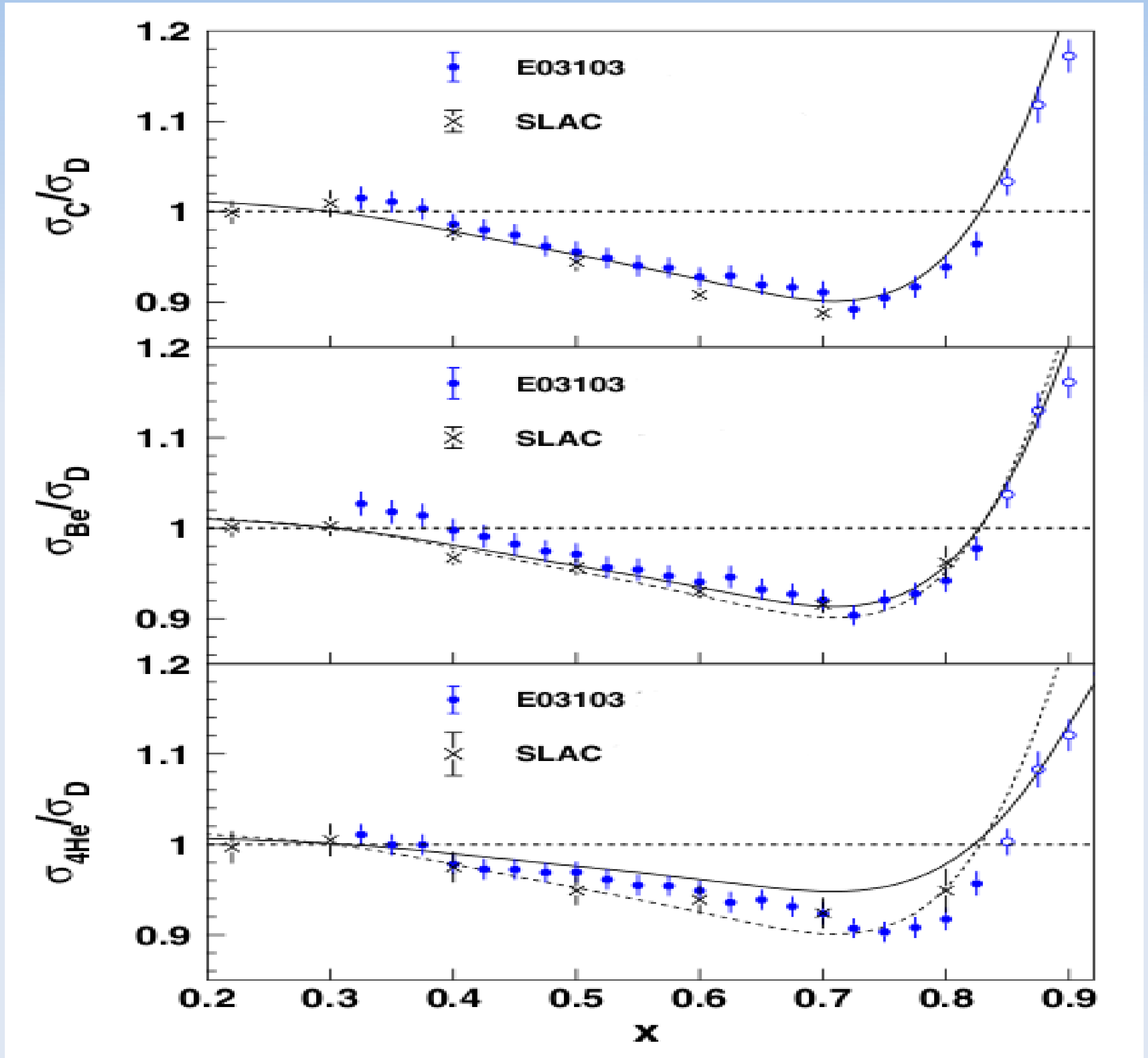




Based on data from J. Gomez et al., Phys. Rev. D 49, 4348 (1994)

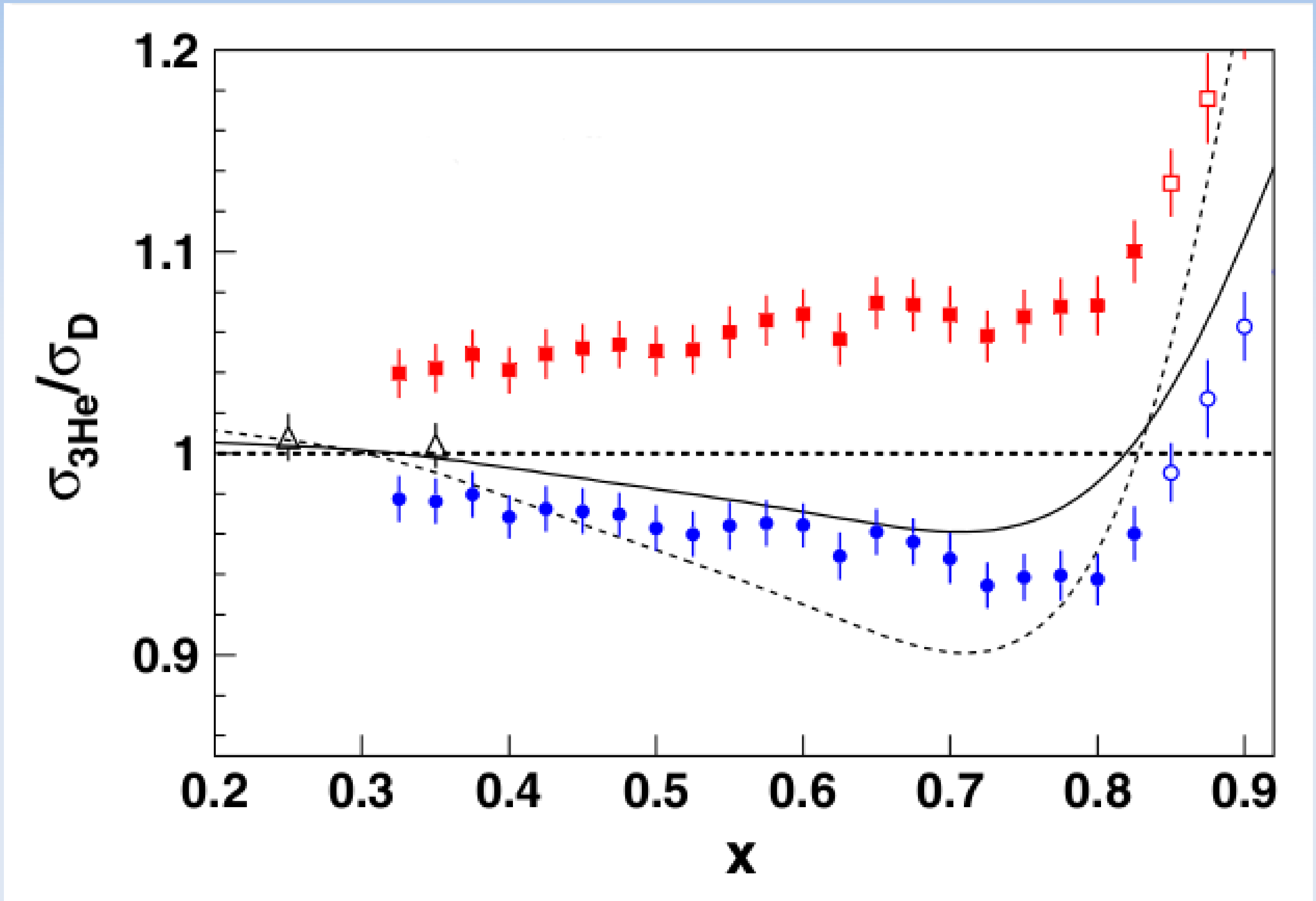
JLab EMC Results

EMC Effect in ^{4}He, ^{9}Be, and ^{12}C



J. Seely et al. PRL 103, 202301 (2009)

EMC Effect in ^{3}He



J. Seely et al. PRL 103, 202301 (2009)